



(12)

**EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**22.05.1996 Bulletin 1996/21**

(51) Int Cl.<sup>6</sup>: **H01Q 3/26**

(21) Application number: **95308223.7**

(22) Date of filing: 16.11.1995

(84) Designated Contracting States:  
**DE FR GB**

(72) Inventor: **Prater, James S.**  
**Fort Collins CO 80524 (US)**

(30) Priority: 18.11.1994 US 342328

(74) Representative: Gill, David Alan et al  
W.P. Thompson & Co.,  
Celcon House,  
289-293 High Holborn  
London WC1V 7HU (GB)

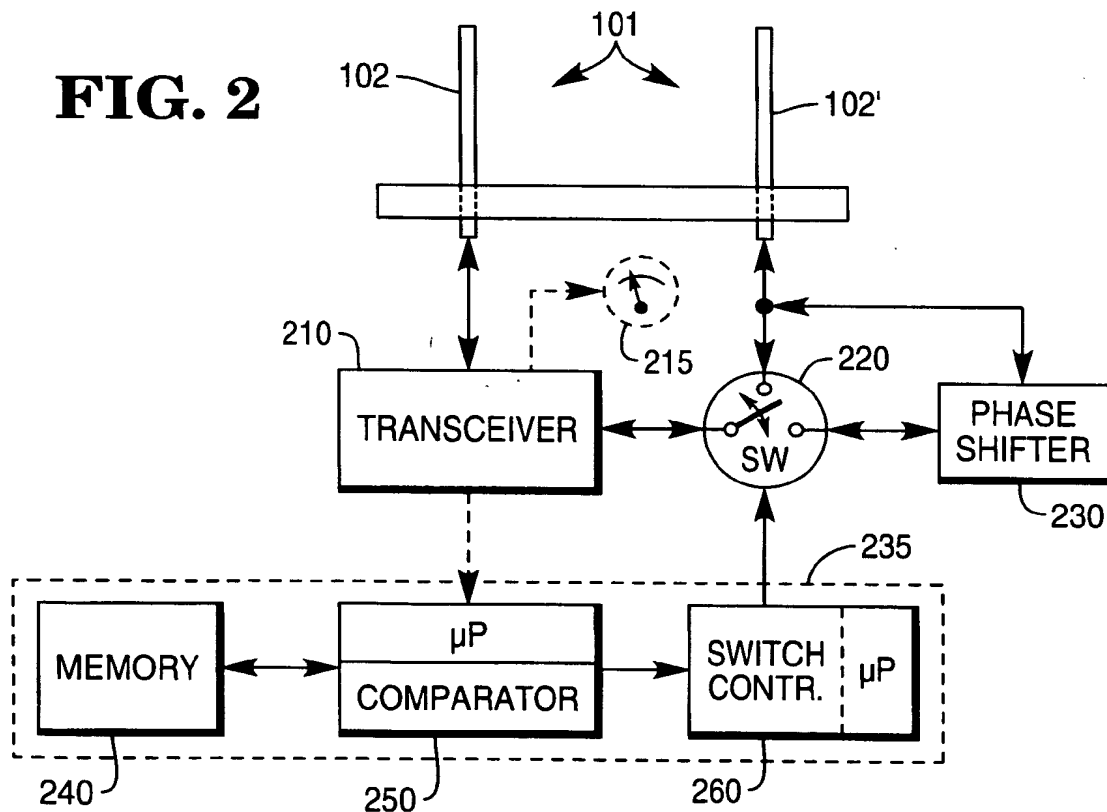
(71) Applicant: **SYMBIOS LOGIC INC.**  
**Fort Collins, Colorado 80525 (US)**

(54) **Antenna apparatus and direction method**

(57) The invention provides for a directional antenna (102,102') connected to a portable communications transceiver (210) and which is arranged to be adaptively directed towards a remote station in a communication system. The amount of RF power required by the port-

able device is then significantly reduced, relative to a non-directional antenna, and the operational period of the transceiver between battery recharges is therefore considerably improved.

**FIG. 2**





## Description

The present invention relates to antenna apparatus and in particular, to a method and apparatus employing adaptive antenna pattern technology to provide improved signal directionality to reduce the power required for communication by a mobile or remote transceiver.

U.S. Patent No. 5,260,968 to Gardner et al. discloses a method for "multiplexing radio communication signals," and uses "blind adaptive spatial filtering of spectrally overlapping signals." This method employs "self [spectral] coherence restoral" techniques which require complicated digital signal processing apparatus to provide the autocorrelation functions necessary to implement the method. Gardener's "adaptive" antenna array is situated at the base station, rather than at the mobile site.

U.S. Patent No. 4,298,873 to Roberts discloses an adaptive antenna which steers toward nulls on an interference source. Roberts' method requires relatively complex hardware to implement the delay line adjustment and amplitude balance necessary for operation of the "null antenna processor."

The present invention seeks to provide for an antenna apparatus and method having advantages over known apparatus and methods.

In accordance with one aspect of the present invention there is provided antenna apparatus comprising antenna means connected to a transceiver means for receiving a first signal from a remote station and for transmitting a second signal to said remote station, and characterised in that said antenna means is adaptable to generate at least one of a plurality of antenna patterns having different directionality, and in that switch means operable with said antenna means is provided for selecting one of said antenna patterns which provides maximum signal strength of said first signal received from said remote station.

Preferably said different antenna patterns have mutually exclusive directions.

In accordance with another aspect of the present invention there is provided a method for directionally adapting antenna apparatus characterised by the steps of receiving, via an antenna having at least two monopole elements a first signal from said remote station and transmitting a second signal to said remote station, determining an optimum antenna patterns which provides a maximum signal amplitude of said first signal received from said remote station and establishing a desired signal phase relationship between each of said monopole elements to generate said optimum antenna pattern.

It should be noted that the method of the present invention can advantageously teach away from the known methods such as Roberts by seeking signal max-  
imums in a received signal.

The invention can prove particularly advantageous in employing an adaptive directional multiple-monopole antenna system.

In accordance with each of a plurality of embodiments of the present invention, a system can advantageously be provided which reduces the power consumption of a cellular phone or other similar remote transceiver. In each of these embodiments an adaptive directional antenna is used to radiate RF power in the direction of the cellular phone (or other) base station instead of radiating the RF power omnidirectionally. The directionality of the antenna is useful for reception as well as transmission, because it increases the strength of the received signal and reduces the amount of noise picked up by the cellular transceiver. The present system is particularly well suited to portable computing applications, such as those using a laptop computer or other remote computing device such as a "personal digital assistant".

One exemplary embodiment of the present system includes a simple adaptive antenna system which can be switched, either manually or via microprocessor, to direct the radiated RF energy into, for example, quadrants or hemispheres in the vicinity of a communicating base station or satellite. This system saves transceiver battery power and compensates for large changes in orientation of the mobile transceiver with respect to the base station/satellite while maximizing signal gain between the transceiver and the base station/satellite.

In a typical cellular phone system, a "handoff protocol" is used to transfer the communication link from one base station to another when the cellular phone (or other transceiver) signal passes from one cell to another cell in the cellular network. In a similar fashion, this same technique may be used to transfer the communication link from one orbiting satellite to another. An alternative embodiment of the present system changes the direction of the transceiver antenna direction to direct the antenna pattern toward the new base station/satellite when a handoff is made.

In yet another embodiment of the present system, the transfer of communications from one cell to another is accomplished via the handoff protocol itself, wherein the cellular phone adapts the antenna configuration whenever a handoff is detected via the communication received from the base station.

Another alternative embodiment of the present system periodically scans for the direction of the strongest return signal. Thus when a handoff is made, the cellular phone automatically adapts the antenna pattern at the next periodic direction scan.

Further additional embodiments of the present invention encompass a variety of directional antenna designs whose radiation patterns can be adapted by changing the phase of the feed signals to different antenna elements. Because space is typically limited in and around mobile computing devices, the antenna may be limited to two elements (for instance, two monopoles mounted on the ends of a notebook computer). Furthermore, since wide antenna pattern lobes are desirable, a simple two-monopole adaptive antenna is well suited

to the present system.

A number of portable cellular devices are presently commercially available. Since all of these portable devices are typically battery powered, the operating period of each device is limited by the battery "life" available between successive recharges. Because the life of a given battery is extended by reducing the power consumption of the device connected to the battery, it follows that reducing the power consumption of a battery powered cellular phone device is highly desirable.

In accordance with each one of a plurality of embodiments of the present invention, methods are provided for adapting an antenna pattern of a remote/mobile cellular transceiver to receive and transmit signals between a base station or satellite and the transceiver so as to establish an energy efficient communication path from the transceiver to the base station. The invention described herein is applicable to either base stations or satellites. The remaining description will describe the use of "base stations", however these techniques are similarly applicable to satellites as well.

Therefore, it is an object of the present invention to reduce the power consumption of a cellular phone or other similar transceiver to provide the advantage of extending the operating life of the transceiver battery.

The present system is particularly advantageous in that the reduction of transceiver power consumption requires only minimal hardware enhancements to existing cellular transceiver systems.

A further advantage of the present invention is that the system enhances the signal-to-noise (S/N) ratio of the signal transmitted (by a transceiver) to a cellular base station, as well as the signal-to-noise ratio of the signals received (by the transceiver) from the base station.

The antenna patterns of the present invention can preferably be bi-directional and can comprise, substantially, two opposingly situated lobes.

The antenna patterns may alternatively merely comprise a unidirectional lobe.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 illustrates an embodiment of the present system wherein two monopole antennas are mounted near the ends of a portable computer;

Fig. 2 is hardware block diagram illustrating one exemplary embodiment of the present invention;

Fig. 3 is a flowchart illustrating one method used for adapting the system antenna configuration;

Fig. 4 is hardware block diagram illustrating two further alternative embodiments of the present invention;

Fig. 5 is a hardware block diagram of an embodiment employing two RF front ends;

Figs. 6 and 7 illustrate overhead views of alternative antenna patterns to which one version of the system may be adapted; and

Fig. 8 shows an overhead view of a cardioid antenna pattern realizable with the present invention.

The present invention can use a directional antenna connected to a portable cellular communications transceiver to adaptively direct the antenna pattern towards a base station in a cellular communication system. The term "cellular communications transceiver," as used in the present application can include any form of mobile or remote transceiver such as a cellular telephone, 2-way pager, wireless LAN or mobile computer using a cellular communications network.

A wide variety portable cellular devices are currently available. For example, PCMCIA ["PC Memory Card International Association"] cards are now available with cellular phone functions built in, and the EO PDA [Personal Digital Assistant] can have a cellular phone option.

Typical cellular phones, for example, use a single monopole antenna and radiate approximately 600 milliwatts of RF power in an omnidirectional pattern in a horizontal plane. A simple directional antenna can easily have a gain of approximately 3dB over that of a monopole antenna. By replacing a single monopole with two monopoles, the radiated power can be reduced to 300 milliwatts, while maintaining the same power density in the direction of the base station.

Since a mobile transceiver changes orientation with respect to cellular phone base stations, if a directional antenna is employed, it must be made directionally adaptive to provide an optimum communications path. One exemplary embodiment of the present system includes a simple adaptive directional antenna system which can direct the RF energy into selected quadrants or hemispheres to allow large changes in orientation relative to a base station while minimizing signal loss. Figs. 6-8, described in detail below, illustrate several possible antenna patterns which can be employed by the system to provide the required directionality.

Fig. 1 shows an embodiment of the present system having an antenna system 101 which uses two monopole antennas 102, 102' mounted near the ends of a portable computer 100. A similar antenna system 101 employing dual-monopole antennas could also be used with mobile or remote transceivers such as cellular telephones, 2-way pagers, and wireless LANs (not shown).

Fig. 2 is hardware block diagram illustrating two possible embodiments of a dual-monopole version of the present system. As shown in Fig. 2, the antenna system 101 comprises two monopole elements 102, 102'.

The antenna element 102 is connected to a transceiver 210, and the antenna element 102' is connected to both a switch 220 and a phase shifter 230. In the simpler of the two embodiments of Fig. 2, an optional comparator block 235 is not used, and a manual switch 220 is used to select alternative antenna patterns by switching phase shifter 230 either in series with transceiver 210 or switching the phase shifter 230 out of the circuit. A transceiver operator may toggle switch 220 to achieve the maximum audio volume, in the case of a cellular phone, for example. Optionally, an operator may toggle switch 220 by referring to a signal strength meter 215 to adapt the antenna to the superior configuration, where a non-audio cellular device is used.

Fig. 3 is a flowchart illustrating one method used for adapting the system antenna configuration between alternative antenna patterns. Figs. 6 and 7 illustrate overhead views of alternate antenna patterns to which the present embodiment of the system may be adapted. The second of the two embodiments shown in Fig. 2 is best described with reference also to Figs. 3, 6, and 7. In this embodiment, a comparator block 235 is included within the arrangement and comprises a signal strength comparator 250 connected between a memory device 240 and a switch controller 260. In operation, at step 305, the comparator 250 initially instructs the switch controller 260 to set the switch 220 in a position which removes phase shifter 230 from the circuit. The antenna elements 102, 102' are thus in phase, and an antenna pattern similar to that shown in Fig. 6 is generated. At step 310, the comparator 250 measures the signal strength of the signal received from the transmitting base station. The comparator 250 may be controlled either by a microprocessor, or by firmware or hardware. The switch controller 260 may optionally be microprocessor or firmware/hardware controlled, and may also provide system control in lieu of the comparator 250. At step 310, the comparator 250 receives a sample of the received signal and stores a value representing the signal strength thereof in the memory device 240. On the initial pass through the flowchart, path 313 is taken, which loops back to step 330.

At step 330, the comparator 250 instructs the switch controller 260 to set the switch 220 in a position which connects the phase shifter 230 back into the circuit, between the antenna element 102' and the transceiver 210. The antenna elements 102, 102' are now out of phase, and an antenna pattern similar to that shown in Fig. 7 is generated. The phase shift imparted by phase shifter 230 is approximately 180 degrees to provide an antenna pattern having lobes which are oriented 90 degrees relative to the in-phase antenna pattern. At step 310, the comparator 250 again measures the signal strength of the signal received from the transmitting base station. At this point, and in all subsequent passes through the flowchart, path 312 is taken to step 320. At step 320, the comparator 250 compares the strength of the present received signal with the value of the previ-

ous signal stored in the memory 240. If the present signal strength is greater than the stored value, then the presently selected antenna pattern is the desired one, and the system waits a predetermined time, at step 340, before again determining which antenna configuration is to be selected.

If, however, the present signal strength is greater than the previously stored value, then, at step 330, the comparator 250 instructs the switch controller 260 to set the switch 220 in a position which connects the phase shifter 230 back to the alternate position, causing the alternative antenna pattern to be generated. In this case, after the comparator 250 executes steps 310 and 320, a branch will be taken to step 340, where the system waits a predetermined time before again determining which antenna configuration is to be selected. Therefore, a cellular communications transceiver operating in accordance with the present invention scans for the direction of signals transmitted from a base station and selects the transceiver antenna pattern which more efficiently receives and radiates RF energy in the general direction of the base station.

Fig. 4 is hardware block diagram illustrating two further alternative embodiments of the present cellular transceiver system, both of which utilize detection of a particular "message" from the base station. In the first of these embodiments, the mobile transceiver attempts to adapt the antenna configuration when a handoff message is detected by the transceiver electronics. In the second embodiment, two messages are sent from the base station to the mobile transceiver to allow the transceiver to determine the more advantageous direction in which to direct the antenna.

In normal operation of a typical cellular phone system, only a single base station is within receiving range of the cellular transceiver. However, when the cellular phone approaches the boundary of a cell, at least two base stations will be within range. In a typical cellular phone system, a handoff protocol is used to transmit a handoff message to a succeeding said base station in an adjacent cell when the signal from said transceiver is stronger in the adjacent cell than in the cell presently communicating with the transceiver. In the present case, wherein a cellular phone system is used with an adaptive antenna, the transceiver antenna direction may need to be changed when the handoff is made, so that the transceiver antenna pattern is directed toward the new base station. In a further alternative embodiment of the present system, this is accomplished by the cellular transceiver which monitors the inter-cell handoff communications. The transceiver attempts to adapt the antenna configuration whenever a handoff is detected. This method is "passive" insofar as the base station is concerned, as there is no special adaptive antenna communications protocol directed to the mobile transceiver.

As shown in Fig. 4, which employs similar reference numerals for components similar to those of Fig. 2, a

message detection circuit 420 is coupled to an adaptive antenna system similar to that described with respect to Figs. 2 and 3. The principle of antenna configuration adaptation of the system shown in Fig. 4 is essentially the same as that shown in Fig. 2, therefore, only the different operational particularities of the present embodiment are described in detail here. It should be noted that microprocessor/memory circuit 240/245 is optional if the comparator 250 or the switch controller 460 has internal firmware (or an internal microprocessor) and memory sufficient to control system operation. If the microprocessor 240 is present, then it is connected to the message detection circuit 420, as well as the comparator 250 and the switch controller 460.

In operation, the message detection circuit 420 receives signals from both antenna elements 102 and 102'. Signals received from element 102' pass through the switch 220, which either directs the signals through the phase shifter 230, or allows the signals to pass directly to the message detection circuit 420, in which case the signals are in phase with those from the antenna element 102. In the present embodiment, an initial signal strength value is stored either in the optional comparator memory 255, or in the microprocessor memory 245, if a separate microprocessor is employed. This signal strength value represents the signal strength of the transmission received from the presently transmitting base station using the existing transceiver antenna configuration. When an inter-cell handoff message is received by the transceiver, the message detection circuit 420 causes the switch controller 460 to toggle the switch 220 which, in turn, causes the antenna 101 to generate an alternative antenna pattern. The comparator 250 then compares the present signal strength with the value stored for the previous antenna configuration. If the present antenna pattern results in a stronger received signal than the previous pattern, then the antenna configuration remains fixed until the next handoff is detected. If, however, the present antenna pattern results in a weaker received signal than the previous pattern, the comparator 250 instructs switch controller 460 to switch the present antenna configuration back to the previous configuration until the next handoff is detected.

It should be noted that if the microprocessor 240 is used, then the message detection circuit 420 communicates via the microprocessor to the switch controller 460, and the comparator 250 uses the microprocessor memory 245 to store the signal strength values.

During periods in which there is no transmission from the base station, a special protocol can be introduced to allow the transceiver antenna to adapt to the preferable configuration. In a further alternative embodiment of the present invention, an "adaptation message" from the base station is repeated twice in a predetermined time interval so that the cellular phone receives the message with the antenna aiming in each of the two directions. The antenna is then set to provide maximum directionality in the direction of the strongest signal from

the base station. Unlike the handoff protocol detection described above, this method requires an additional component of the base station protocol specifically directed to the mobile transceiver. This method is useful for providing antenna direction orientation when the base station is not otherwise transmitting a signal on which the mobile transceiver can "home in".

The principle of operation of the "adaptation message" embodiment is similar to that of the "handoff message" embodiment described above, therefore, only the different operational particularities of the present embodiment are described in detail. As shown in Fig. 4, the present system can utilize a message detection circuit 420 to detect the occurrence of an adaptation message transmitted from a base station. In operation, when an adaptation message is received by the transceiver, a signal strength value is stored either in the optional comparator memory 255, or in the microprocessor memory 245, if a separate microprocessor is employed. This signal strength value represents the signal strength of the transmission received from the presently transmitting base station using the existing transceiver antenna configuration. Immediately thereafter, the message detection circuit 420 causes the switch controller 460 to toggle the switch 220 which, in turn, causes the antenna system 101 to exhibit an alternate antenna pattern. When the second adaptation message is detected, the comparator 250 compares the present signal strength with the value stored for the previous antenna configuration. If the present antenna pattern results in a stronger received signal than the previous pattern, then the antenna configuration remains fixed until the next adaptation message is detected. If, however, the present antenna pattern results in a weaker received signal than the previous pattern, then comparator 250 signals switch controller 460 to switch the present antenna configuration back to the previous configuration until the next adaptation message is detected.

Fig. 5 is a hardware block diagram of an embodiment employing two RF front end receivers ("front ends") 510, 510'. As shown in Fig. 5, a phase shifter 230 is hardwired into the system to provide a fixed phase difference, typically 180 degrees, between the signals input to, and output from, the front ends 510, 510'. In operation, the signals from the antenna elements 102, 102' are processed by the front ends 510, 510', respectively, at the same time. In this case no special protocol or message is required, as the comparator 250 measures the signal strength from both antenna configurations and instructs the switch 220 to select the configuration providing the stronger signal, which is applied to the transceiver 210. Alternatively, two (or more) different antennas with fixed patterns can be used, each pointing in a different direction.

There are many directional antenna designs whose radiation patterns can be adapted by changing the phase of the feed signals to different antenna elements. Because space is limited in mobile computing devices,

the antenna may be limited to 2 or 3 elements (for instance, two monopoles mounted on the ends of a portable computer). Because wide antenna pattern lobes are desirable, a simple adaptive antenna having two monopole elements is well suited to this application. Figs. 6 and 7 show a pair of corresponding antenna patterns obtained by changing the phase of the signals transmitted or received by the two monopole antenna elements.

Fig. 6 is an overhead view of an antenna system having monopole elements 602, 602' separated by spacing SP1, which is preferably one-half wavelength of the transmitted/ received signal. It can be seen that lobes 610, 610' are oriented along an East/West (E/W) axis, and nulls N1, N2 are oriented along a North/South (N/S) axis. This antenna pattern is generated when the signals received by or applied to elements 602 and 602' are in phase with each other.

Fig. 7 is another overhead view of the antenna system shown in Fig. 6. It can be seen that lobes 610, 610' are oriented along the N/S axis, and nulls N3, N4 are oriented along the E/W axis. This antenna pattern is generated when the signals received by, or applied to, the elements 602 and 602' are 180 degrees out-of-phase with each other. The antenna system depicted in Figs. 6 and 7 is essentially "bi-directional".

Regardless of whether a dual monopole or dual dipole antenna system is employed, the antenna pattern is chosen which maximizes return signal from the base station with which the portable device is communicating. This signal maximization is accomplished by using each of the available antenna patterns and measuring the amount of signal power received at the cellular phone from the base station for each antenna pattern configuration.

Fig. 8 is an overhead view of an antenna pattern realizable by using a pair of dipole elements. The cardioid antenna pattern thus generated is typically more directional than the pattern generated by a monopole element pair such as illustrated in Figs 6-7. As shown in Fig. 8, dipole elements 802, 802' are separated by a spacing SP2, which is typically 1/4 wavelength. When an in-phase signal is applied to elements 802 and 802', a resultant cardioid pattern 810 is generated. When the applied signal is 90 degrees out-of-phase, for example, the antenna pattern shown in Fig. 8 is generated. As the relative phase between the dipole elements is changed, the direction of the main lobe 810 exhibits a corresponding rotational displacement about point C. As can be seen from Fig. 8, such a cardioid antenna pattern is substantially unidirectional, with a main lobe 810 in direction N in this case. In an alternative embodiment, the elements 802 and 802' could be monopoles, instead of dipoles. In a further alternative embodiment, regardless of whether the antenna elements 802, 802' are monopoles or dipoles, an alternative antenna pattern could be selected wherein a null is directed toward the user of the transceiver, so as to minimize the radiated RF energy

in the direction of the user.

It should be noted that the present method is functional with any number of monopole or dipole elements whose spacing and phase relationship permits generation of more than two alternative configurations.

The invention is not limited to the details of the foregoing embodiments but encompasses other modifications and alterations within the scope of the present inventive concept.

## Claims

1. Antenna apparatus comprising antenna means (102,102') connected to a transceiver means (210) for receiving a first signal from a remote station and for transmitting a second signal to said remote station, and characterised in that said antenna means (102,102') is adaptable to generate at least one of a plurality of antenna patterns having different directionality, and in that switch means (220) operable with said antenna means (102,102'), is provided for selecting one of said antenna patterns which provides maximum signal strength of said first signal received from said remote station.
2. Apparatus as claimed in Claim 1, wherein said switch means (220) is manually operable.
3. Apparatus as claimed in Claim 1 or 2, wherein said antenna means (102,102') comprises two monopole antennas, and said system further includes phase shift means (230) operable with said switch means (220) for establishing a desired signal phase relationship between the two monopole antennas to adapt said antenna means (102,102') so as to generate a desired one of said antenna patterns.
4. Apparatus as claimed in Claim 1 or 2, wherein said antenna means (102,102') comprises more than two monopole antennas, and phase shift means (230) are provided operable with said switch means (220) for establishing a desired signal phase relationship between said monopole antennas.
5. Apparatus as claimed in Claim 1, wherein said antenna means (102,102') comprises two monopole elements, and the apparatus further includes comparator means (250) connected to said antenna means (102,102') and operable by way of said switch means (220) for determining an optimum one of said antenna patterns which provides a maximum signal amplitude of said first signal received from said remote station, phase shift means (230) connected to said antenna means (102,102') for establishing a desired signal phase relationship between each of said monopole elements; and wherein said switch means is responsive to said comparator

means (250) and operable with said phase shift means (230) for selecting the antenna pattern (250) which provides maximum signal strength of said first signal received from said remote station.

6. Apparatus as claimed in any one of Claims 1 to 5, wherein said switch means (220) can periodically select each of said antenna patterns in a cyclical fashion to determine which one of said antenna patterns provides said maximum signal strength of said first signal received from said remote station.
7. Apparatus as claimed in any one of Claims 1 to 6, wherein said second signal is transmitted via the one of said antenna patterns used to receive the most recent said first signal.
8. Apparatus as claimed in any one of Claims 1 to 7, wherein said plurality of antenna patterns comprises two antenna patterns wherein each of said antenna patterns is bidirectional and consists substantially of two oppositely situated lobes, each of said antenna patterns is oriented approximately 90 degrees to each other, a first one of said antenna patterns is generated by establishing a first phase relationship of 0 degrees, and a second one of said antenna patterns is generated by establishing a second said phase relationship of 180 degrees.
9. Apparatus as claimed in Claim 4 or 5, wherein said plurality of antenna patterns comprises antenna N patterns in which each of said antenna patterns consists substantially of a unidirectional lobe oriented approximately  $360/N$  degrees to an adjacent lobe, and each of said antenna patterns is generated by establishing an appropriate phase relationship between the antennas.
10. Apparatus as claimed in any one of Claims 1 to 9, wherein said remote station periodically transmits a locator message pair comprising a first instance of a locating message followed by a second instance of said locating message, and further comprising memory means (255) for storing a signal strength value detection means (420) interconnected between said antenna means (102,102') and said switch means (220) for detecting said first instance of said locating message, storing a value representing the signal strength of said first instance in said memory means (255), causing said switch means (220) to select an alternate one of said antenna patterns in response to detection of said first locating message, and for detecting said second instance of said locating message, and wherein said comparator means (250) is arranged to compare said value stored in said memory means (255) with the signal strength of said second instance, and to operate said switch means (220) to select one of the

antenna patterns which provides greater signal strength of said locating message.

11. Apparatus as claimed in any one of Claims 1 to 9, wherein said remote station comprises a base station located in a first cell of a cellular communications network, and wherein a handoff protocol is used to transmit a handoff message to a succeeding base station in a second cell of said network when said second signal from said transceiver is stronger in said second cell than in said first cell, said apparatus further including memory means (255) for storing a signal strength value, detection means (420) interconnected between said antenna means (102, 102') and said switch means (220) for detecting said handoff message, storing a value representing the signal strength of said first signal in said memory, and causing said switch means (220) to select an alternative one of said antenna patterns in response to said detected message, and wherein said comparator means (250) is arranged to compare said value stored in said memory means (255) with the signal strength of said first signal received by said alternative one of said antenna patterns and to operate said switch means (220) to select one of the antenna patterns which provides greater signal strength of said first signal.
12. Apparatus as claimed in any one of Claims 1-11, wherein said antenna means comprises two monopole antennas (102,102') having a first configuration in which a first phase relationship exists between said monopole elements and said apparatus further comprising phase shift means (230) for establishing a second configuration in which a second phase relationship exists between said monopole elements, comparator means (250) for determining a relative signal strength of two signals and two RF receiver means (510,510') each of which is connected between a different one of each of said antennas (102,102') and said comparator means (250), wherein said comparator means (250) operable with said switch means (220) to connect said transceiver (210) to the configuration which provides the stronger relative signal strength.
13. A method for directionally adapting antenna apparatus characterised by the steps of receiving, via an antenna having at least two monopole elements (102,102') a first signal from a remote station and transmitting a second signal to said remote station, determining an optimum antenna pattern which provides a maximum signal amplitude of said first signal received from said remote station and establishing a desired signal phase relationship between each of said monopole elements to generate said optimum antenna pattern.

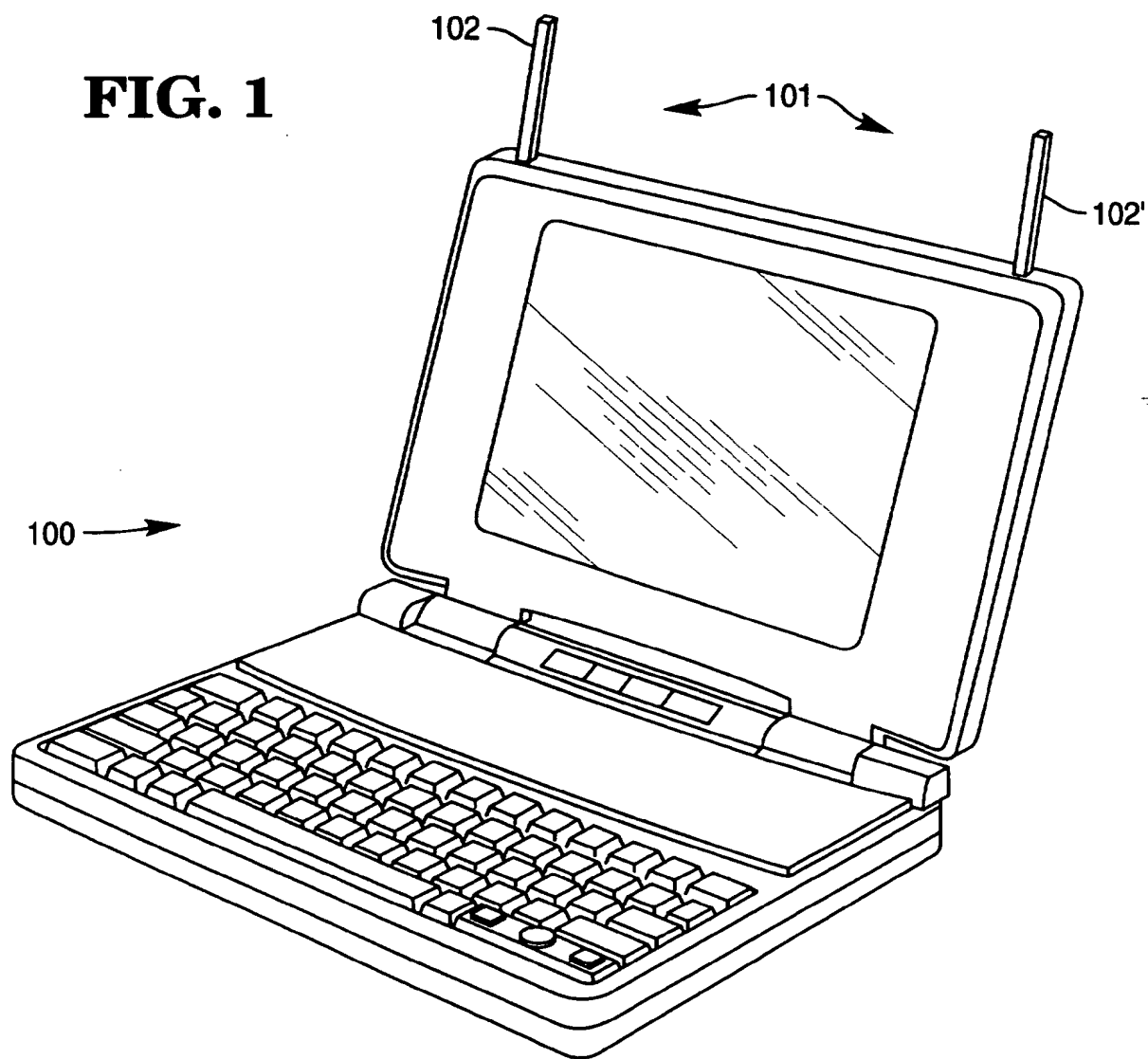
14. A method as claimed in Claim 13 and including the step of periodically selecting each of said antenna patterns in a cyclical fashion to determine which said antenna pattern provides said maximum signal strength of said first signal received from said remote station. 5
15. A method as claimed in Claim 13 or 14, wherein said remote station periodically transmits a locator message pair comprising a first instance of a locating message followed by a second instance of said locating message and including the step of periodically transmitting, from said remote station, a locator message pair consisting of a first instance of a locating message followed by a second instance of said locating message, and, at a transceiver site, detecting said first instance of said locating message, storing a value representing the signal strength of said first instance in memory selecting an alternative antenna pattern in response to detection of said first locating message, detecting said second instance of said locating message, comparing said value stored in said memory with the signal strength of said second instance, and selecting one of the antenna patterns which provides greater signal strength of said locating message. 10 15 20 25
16. A method as claimed in Claim 13 or 14, wherein said remote station comprises a base station located in a first cell of a cellular communications system, and wherein a handoff protocol is used to transmit a handoff message to a succeeding base station in a second cell when said second signal from said transceiver is stronger in said second cell than in said first cell, and further including the steps of detecting said handoff message, storing a value representing the signal strength of said first signal in memory, selecting an alternative one of said antenna patterns in response to said detecting, comparing said value stored in said memory with the signal strength of said first signal received by said alternative one of said antenna patterns and selecting one of the antenna patterns which provides greater signal strength of said first signal. 30 35 40 45

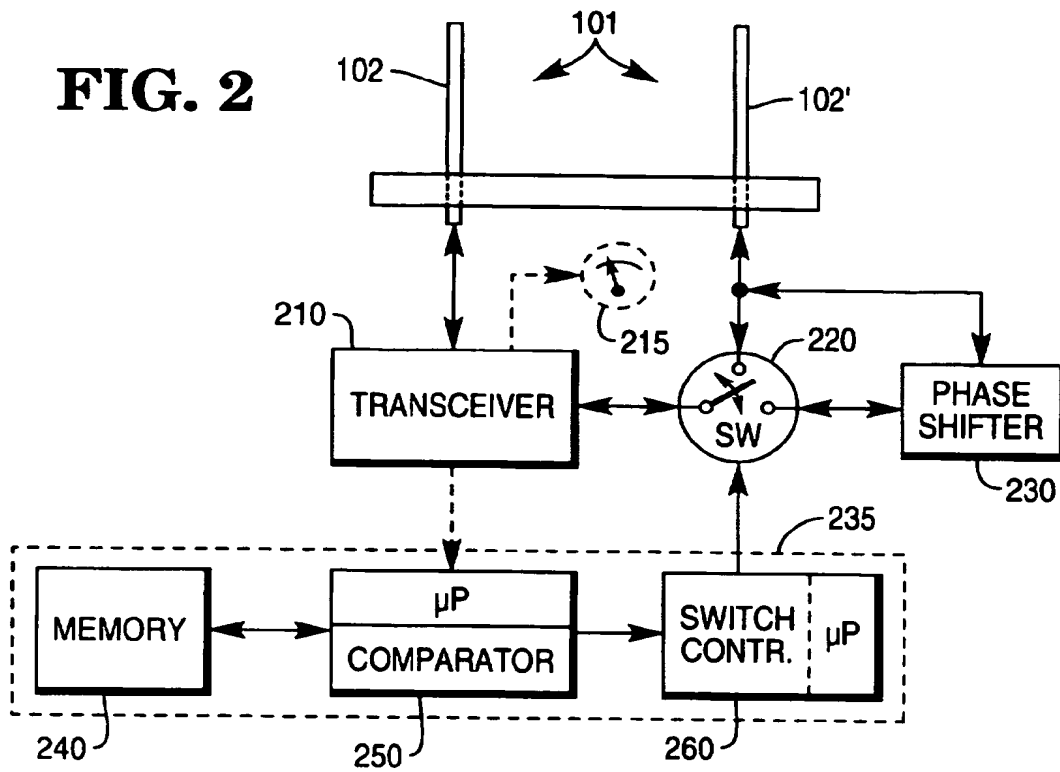
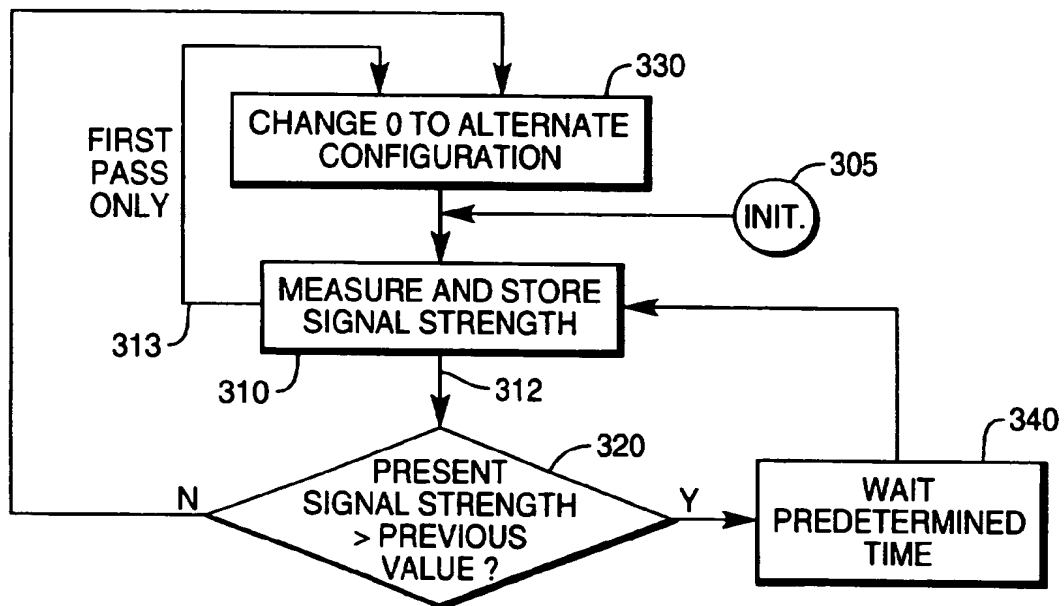
50

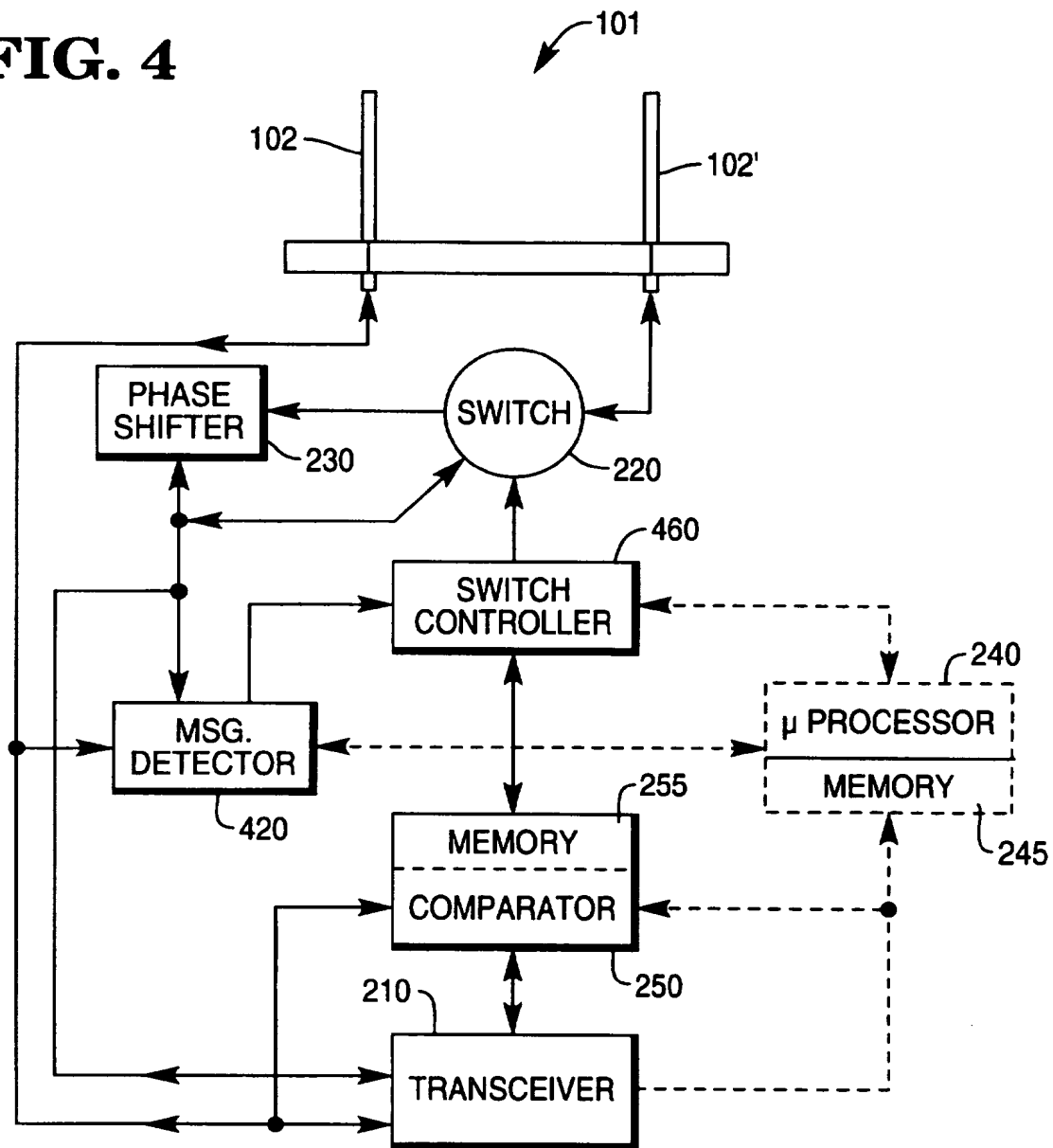
55

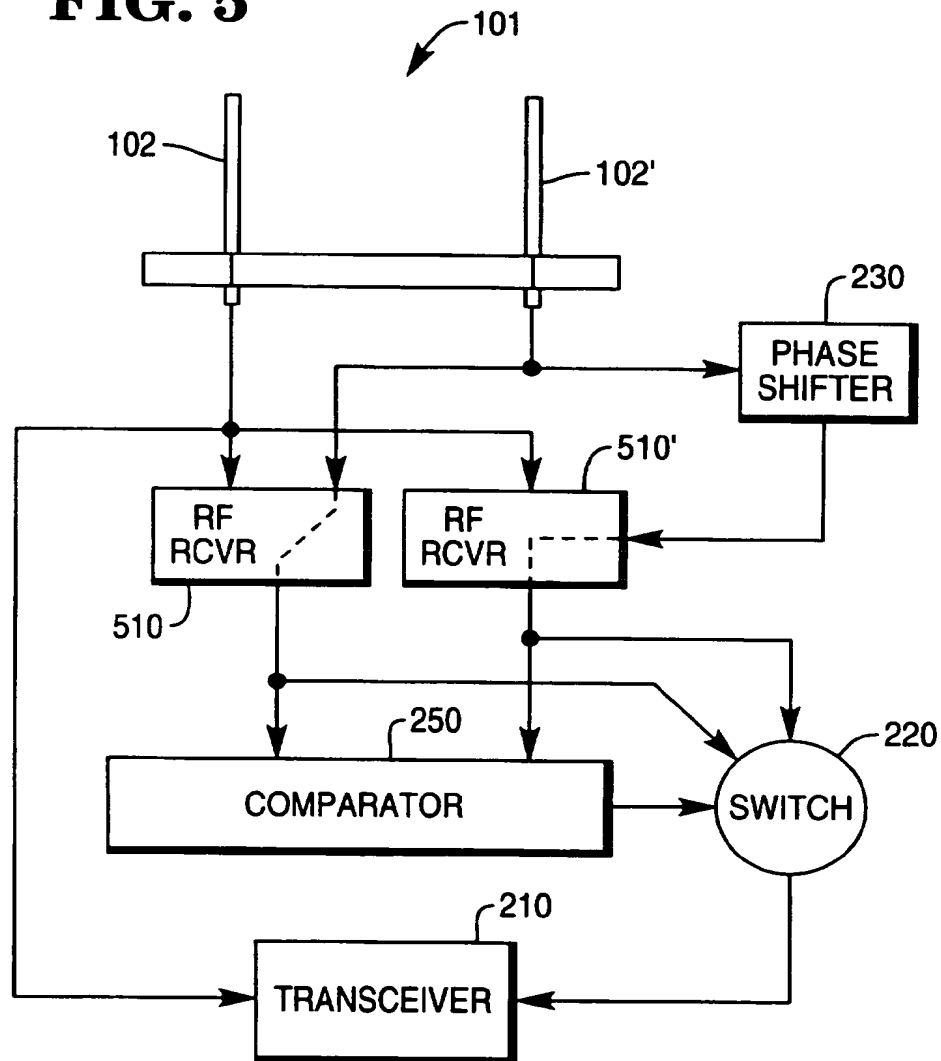


**FIG. 1**

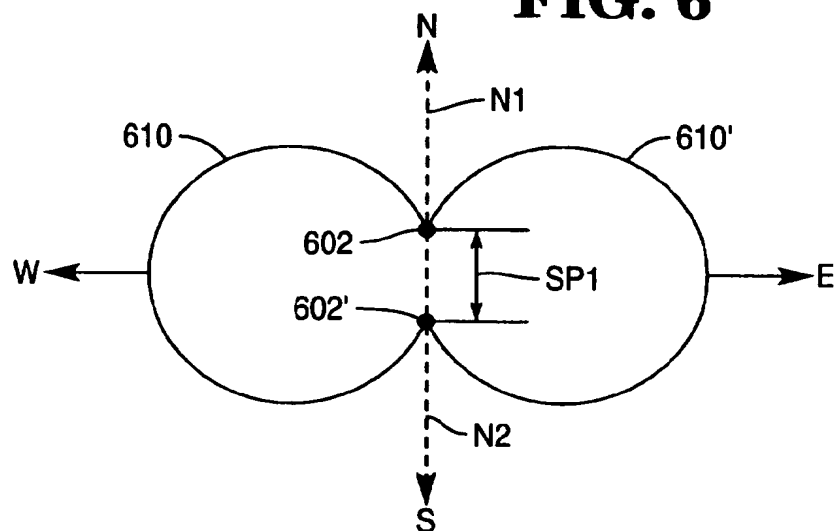


**FIG. 2****FIG. 3**

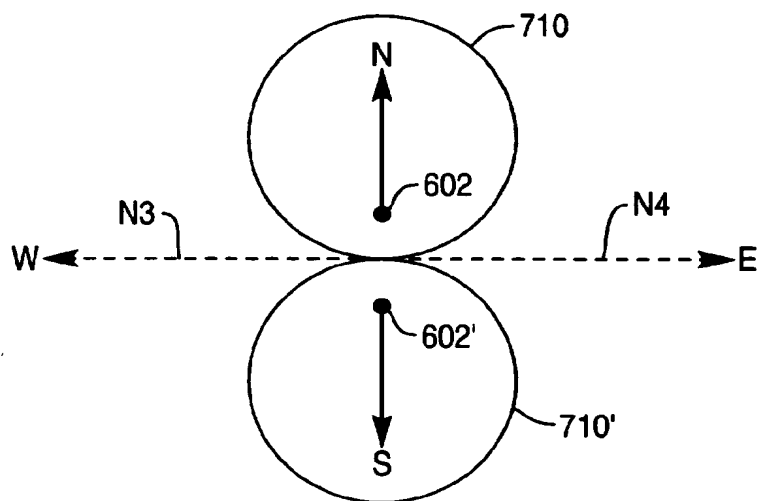
**FIG. 4**

**FIG. 5**

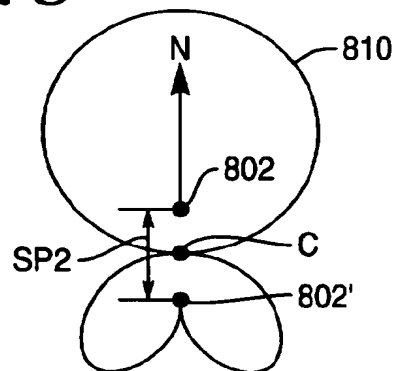
**FIG. 6**

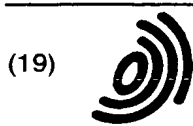


**FIG. 7**



**FIG. 8**





Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11) **EP 0 713 262 A3**

(12) **EUROPEAN PATENT APPLICATION**

(88) Date of publication A3:  
11.09.1996 Bulletin 1996/37

(51) Int Cl.<sup>6</sup>: **H04B 7/08, H01Q 3/26**

(43) Date of publication A2:  
22.05.1996 Bulletin 1996/21

(21) Application number: **95308223.7**

(22) Date of filing: **16.11.1995**

(84) Designated Contracting States:  
**DE FR GB**

(72) Inventor: **Prater, James S.**  
**Fort Collins CO 80524 (US)**

(30) Priority: **18.11.1994 US 342328**

(74) Representative: **Gill, David Alan et al**  
**W.P. Thompson & Co.,**  
**Celcon House,**  
**289-293 High Holborn**  
**London WC1V 7HU (GB)**

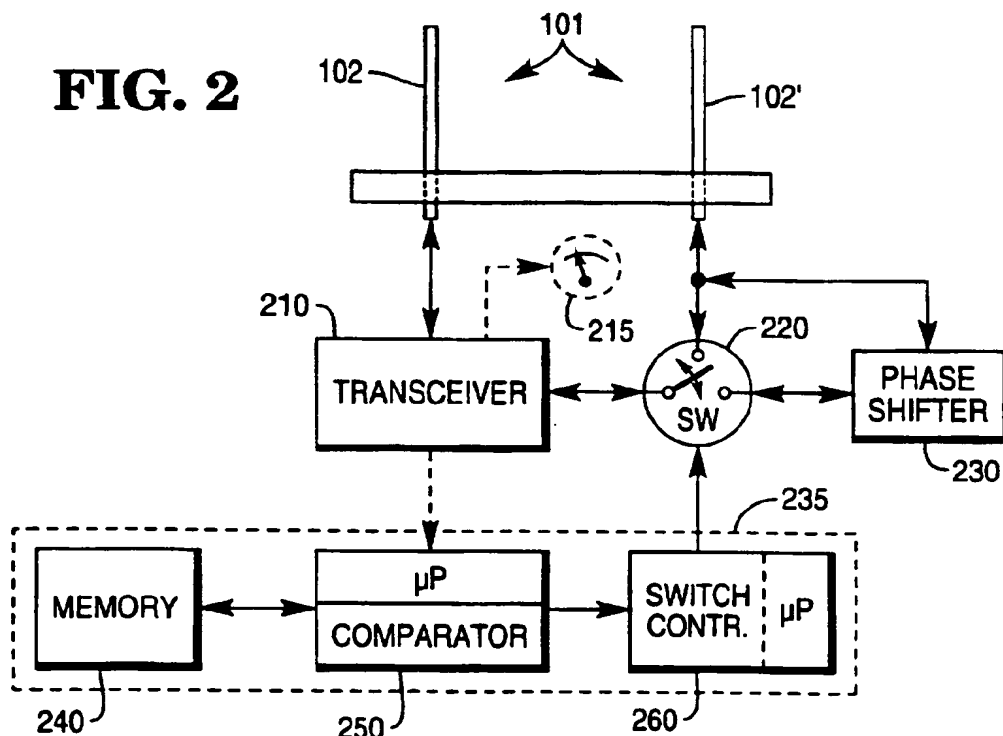
(71) Applicant: **SYMBIOS LOGIC INC.**  
**Fort Collins, Colorado 80525 (US)**

(54) **Antenna apparatus and direction method**

(57) The invention provides for a directional antenna (102,102') connected to a portable communications transceiver (210) and which is arranged to be adaptively directed towards a remote station in a communication

system. The amount of RF power required by the portable device is then significantly reduced, relative to a non-directional antenna, and the operational period of the transceiver between battery recharges is therefore considerably improved.

**FIG. 2**





European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 95 30 8223

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	FR-A-2 512 611 (NIPPON TELEGRAPH & TELEPHONE PUBLIC CORP.) * figures 1-3A, 11 * * page 5, line 5 - line 18 * * page 5, line 34 - line 37 * ---	1,3	H04B7/08 H01Q3/26
Y	PATENT ABSTRACTS OF JAPAN vol. 15, no. 482 (E-1142), 6 December 1991 & JP-A-03 210830 (CLARION CO. LTD.), 13 September 1991, * abstract *	1,3	
Y	EP-A-0 352 787 (MOTOROLA INC.) * abstract; figures 1A, 3 * * page 5, line 19 - line 26 *	1,5	
Y	US-A-3 357 018 (VILLARD, JR.) * figures 1, 2A-2C, 6 * * column 4, line 20 - line 30 *	1,5	
A	PATENT ABSTRACTS OF JAPAN vol. 17, no. 156 (E-1341), 26 March 1993 & JP-A-04 320122 (NIPPON TELEGR. & TELEPH. CORP.), 10 November 1992, * abstract *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6)  H04B H01Q
A	PATENT ABSTRACTS OF JAPAN vol. 14, no. 461 (E-0987), 5 October 1990 & JP-A-02 186728 (HITACHI LTD.), 23 July 1990, * abstract *	1,4	
A	US-A-5 117 236 (CHANG ET AL.) * figures 1-7 * * column 1, line 16 - line 25 * * column 2, line 39 - line 45 * * column 6, line 66 - column 7, line 1 * --- -/--	9,11	
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 5 July 1996	Examiner Danielidis, S
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons - : member of the same patent family, corresponding document</p>			

EPO FORM 1503 (01.92) (P04C01)



European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 95 30 8223

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP-A-0 124 319 (AT&T)  * abstract; figures 1,2,6 * * page 4, line 28 - line 32 * * claims 1-3 *	1,10,13,14	
A	US-A-4 710 944 (NOSSEN) * abstract; figure 1 * -----	10,15	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 5 July 1996	Examiner Danielidis, S
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone  Y : particularly relevant if combined with another document of the same category  A : technological background  O : non-written disclosure  P : intermediate document</p> <p>T : theory or principle underlying the invention  E : earlier patent document, but published on, or after the filing date  D : document cited in the application  L : document cited for other reasons  .....  &amp; : member of the same patent family, corresponding document</p>			

EPO FORM 150 (2.12.1994)